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Epitome

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(57) [Abstract]
[Technical problem] The temperature change of a permanent-magnet type synchronous motor is presumed, and highly efficient control is performed.
[Means for Solution] q shaft electrical potential difference is extracted from the output of the electrical-potential-difference detector which detects the input voltage of a permanent-magnet type synchronous motor, and an electrical-potential-difference detector. Have the voltage component converter to output and it has the rate detector which detects the rotational speed of a permanent-magnet type synchronous motor. The temperature presumption machine which carries out the setting storage of the primary resistance of a permanent-magnet type synchronous motor at a setting storage means, and presumes the temperature change of a permanent-magnet type synchronous motor from the primary resistance of d shaft current, q shaft current, q shaft electrical potential difference, rotational speed, and a setting storage means, and magnetic flux, A magnetic-flux correction means to correct the magnetic flux used for q shaft current command calculation machine from the magnetic flux of a setting storage means and the output of a temperature presumption machine is provided.

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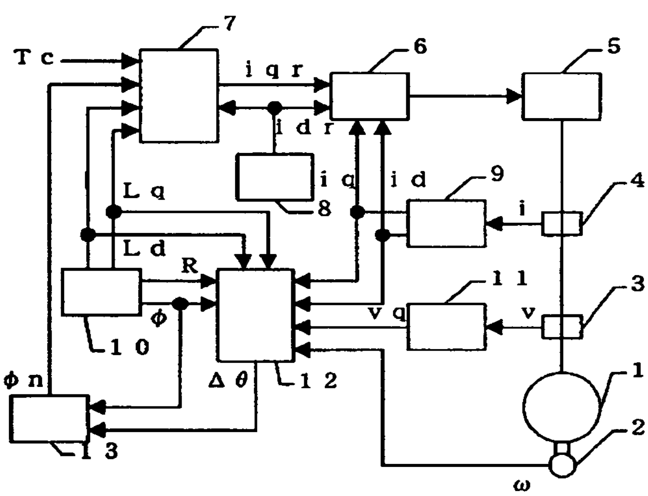

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CLAIMS

[Claim(s)]

[Claim 1] The control unit of the permanent-magnet type synchronous motor characterized by providing the following. The current detector which detects the input current supplied to the permanent-magnet type synchronous motor in the control unit of a permanent-magnet type synchronous motor through the power converter which makes a current limiter output a control input The current component converter which carries out the conversion output of this current detector output at the permanent magnet of said permanent-magnet type synchronous motor, parallel d shaft current, and perpendicular q shaft current The setting storage means which carries out the setting storage of the magnetic flux and primary resistance of said permanent magnet d shaft current command calculation machine which computes d shaft current command, and q shaft current command calculation machine which computes q shaft current command from the output-torque command value of said permanent-magnet type synchronous motor, the magnetic flux of said setting storage means, and d shaft current command, The current limiter which considers said d shaft current and q shaft current and d shaft current command, and q shaft current command as an input, The electrical-potential-difference detector which detects or presumes the input voltage of said permanent-magnet type synchronous motor, The voltage component converter which outputs said permanent magnet and perpendicular q shaft electrical potential difference from this electrical-potential-difference detector output, The temperature presumption machine which presumes the temperature change of said permanent-magnet type synchronous motor from the rate detector which detects the rotational speed of said permanent-magnet type synchronous motor, and the primary resistance of the aforementioned d shaft current, q shaft current, q shaft electrical potential difference, rotational speed, and a setting storage means and each value of magnetic flux
[Claim 2] The control unit of the permanent-magnet type synchronous motor according to claim 1 characterized by providing a magnetic-flux correction means to correct the magnetic flux used for said q shaft current command calculation machine from the magnetic flux of said setting storage means, and said temperature presumption machine output.

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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention improves fluctuation of the torque precision especially by the temperature change about the torque control in a permanent-magnet type synchronous motor.
[0002]
[Description of the Prior Art] An example of the conventional technique is shown in drawing 2 , and this is explained. A power converter 5 supplies power to the permanent-magnet type synchronous motor 1. The current detector 4 detects the input current i of the permanent-magnet type synchronous motor 1. The current component converter 9 considers an input current i as an input, and outputs the permanent magnet of the permanent-magnet type synchronous motor 1, the parallel d shaft current id, and the perpendicular q shaft current iq. The setting storage means 10 carries out the setting storage of the magnetic flux phi of d shaft inductance Ld of the permanent-magnet type synchronous motor 1, q shaft inductance Lq, and a permanent magnet.
[0003] q shaft current command calculation machine 7 inputs the magnetic flux phi of the torque command Tc, d shaft current command idr, d shaft inductance Ld and q shaft inductance Lq, and a permanent magnet, and outputs q shaft current command iqr. d shaft current command calculation machine 8 outputs d shaft current command idr. A current limiter 6 inputs the d shaft current id, the q shaft current iq, d shaft current command idr, and q shaft current command iqr, and it outputs a control signal to a power converter 5 so that each

current value may follow a command value.
[0004]
[Problem(s) to be Solved by the Invention] The torque type of a permanent-magnet type synchronous motor is expressed with a degree type.
[0005]

$$T=\phi \bullet i_q + \left(L_d - L_q\right) \bullet i_d \bullet i_q \qquad (1)$$

[0006] (1) q shaft current command iqr is called for like a degree type from a formula.
[0007]

$$i_{qr} = \frac{T}{\phi + \left(L_d - L_q\right) \bullet i_{dr}} \qquad (2)$$

[0008] (2) From a formula, q shaft current command iqr is computed using the magnetic flux phi of d shaft inductance Ld of a permanent-magnet type synchronous motor, q shaft inductance Lq, and a permanent magnet. However, since the magnetic flux phi of a permanent magnet is changed by the temperature change of a permanent-magnet type synchronous motor, if it fixes the magnetic flux phi of a permanent magnet, q shaft current command value iqr of (2) types will not be computed by the temperature change as a right value, but it will bring a result to which the control precision of the output torque of a permanent-magnet type synchronous motor is changed. The place which this invention was originated in view of the point mentioned above, and is made into the purpose solves the above-mentioned trouble by preparing the function to presume the temperature change of a permanent-magnet type synchronous motor, and to correct fluctuation by the temperature change of the magnetic flux of a permanent magnet, and makes highly precise further the torque control of a permanent-magnet type synchronous motor.
[0009]
[Means for Solving the Problem] The current detector which detects the input current supplied to a permanent-magnet type synchronous motor through the power converter which makes a current limiter output a control input in order to solve the above-mentioned trouble, This current detector output The permanent magnet of said permanent-magnet type synchronous motor, and parallel d shaft current, The current component converter which carries out a conversion output at perpendicular q shaft current, and the setting storage means which carries out the setting storage of the magnetic flux and primary resistance of said permanent magnet, d shaft current command calculation machine which computes d shaft current command, and q shaft current command calculation machine which computes q shaft current command from the output-torque command value of said permanent-magnet type synchronous motor, the magnetic flux of said setting storage means, and d shaft current command, The current limiter which considers said d shaft current and q shaft current and d shaft current command, and q shaft current command as an input, The electrical-potential-difference detector which detects or presumes the input voltage of said permanent-magnet type synchronous motor, The voltage component converter which outputs said permanent magnet and perpendicular q shaft electrical potential difference from this electrical-potential-difference detector output, The temperature presumption machine which presumes the temperature change of said permanent-magnet type synchronous motor from the rate detector which detects the rotational speed of said permanent-magnet type synchronous motor, the primary resistance of the aforementioned d shaft current, q shaft current, q shaft electrical potential difference, rotational speed, and a setting storage means, and each value of magnetic flux is provided.
[0010] Moreover, a magnetic-flux correction means to correct the magnetic flux used for said q shaft current command calculation machine from the magnetic flux of said setting storage means and said temperature presumption machine output is provided.
[Embodiment of the Invention]
[0011] The example of this invention is shown in drawing 1 , and this drawing is explained hereafter. In addition, explanation of the same part as the above-mentioned conventional technical example is omitted. The rate detector 2 outputs the rotational speed omega of the permanent-magnet type synchronous motor 1. The electrical-potential-difference detector 3 detects or presumes the input voltage v of the permanent-magnet type synchronous motor 1. The voltage component converter 11 outputs the permanent magnet of the permanent-magnet type synchronous motor 1, and perpendicular q shaft electrical potential difference vq from input voltage v.

[0012] The temperature presumption machine 12 inputs the magnetic flux phi of the d shaft current id, the q shaft current iq, q shaft electrical potential difference vq, rotational speed omega and d shaft inductance Ld, q shaft inductance Lq, primary resistance R, and a permanent magnet, and outputs temperature-change deltatheta of the permanent-magnet type synchronous motor 1. The magnetic-flux correction means 13 inputs the magnetic flux phi of a permanent magnet, and temperature-change deltatheta, and outputs magnetic-flux phin of the corrected permanent magnet.
[0013] The point that q shaft current command calculation machine 7 differs from the conventional technique is a point of using magnetic-flux phin of the corrected permanent magnet. The point that the setting storage means 10 differs from the conventional technique is a point which is carrying out the setting storage of the primary resistance R.
[0014] Here, this invention explains two reasons which can solve said trouble. The first, it is a reason for the ability to presume the temperature change of a permanent-magnet type synchronous motor, and the second is a reason for acquiring effectiveness with a magnetic-flux correction means. First, it is about the reason for the ability to presume the temperature change of a permanent-magnet type synchronous motor, and, in the first place, the detail of the temperature presumption machine 12 is explained. q shaft electrical-potential-difference equation of the permanent-magnet type synchronous motor 1 is expressed with a degree type.
[0015]

$$v_q = \omega \cdot L_d \cdot i_d + \left(R + p \cdot L_q\right) \cdot i_q + \omega \cdot \phi \qquad (3)$$

[0016] Here, p is a differential operator. (3) In a formula, some which are changed by temperature-change deltatheta have the magnetic flux phi and primary resistance R of a permanent magnet. The amounts of fluctuation of the magnetic flux phi of a permanent magnet and primary resistance R by temperature-change deltatheta are temperature-change deltatheta and proportionality. Therefore, magnetic-flux phin of an actual permanent magnet and primary resistance Rn can be expressed with the relation of a degree type.
[0017]

$$R_n = \left(1 + g_1 \cdot \Delta\theta\right) \cdot R \qquad (4)$$

[0018]

$$\phi_n = \left(1 + g_2 \cdot \Delta\theta\right) \cdot \phi \qquad (5)$$

[0019] However, g1 and g2 are temperature coefficients. Therefore, if (4) types of the actual primary resistance Rn and (5) types of magnetic-flux phin of a permanent magnet are substituted for (3) types, temperature-change deltatheta will become a degree type.
[0020]

$$\Delta\theta = \frac{v_q - \omega \cdot L_d \cdot i_d - \left(R + p \cdot L_q\right) \cdot i_q - \omega \cdot \phi}{g_1 \cdot R \cdot i_q + g_2 \cdot \omega \cdot \phi} \qquad (6)$$

[0021] Therefore, with the temperature presumption vessel 12, the degree type which transformed (6) types is calculated and temperature-change deltatheta is presumed.
[0022]

$$\Delta\theta = K \int \Big[\left\{ v_q - \omega \cdot L_d \cdot i_d - \left(R + p \cdot L_q\right) \cdot i_q - \omega \cdot \phi \right\} - \Delta\theta \cdot \left(g_1 \cdot R \cdot i_q - g_2 \cdot \omega \cdot \phi \right) \Big] \cdot dt \qquad (7)$$

[0023] Here, K is an integration constant. if temperature-change deltatheta is small -- [of (7) types --] -- if an inner operation value serves as forward, temperature-change deltatheta is made to increase and temperature-change deltatheta is conversely large -- [of (7) types --] -- temperature-change deltatheta can be presumed by an inner operation value serving as negative and decreasing temperature-change deltatheta. As explained above, temperature-change deltatheta of a permanent-magnet type synchronous motor can be presumed from the magnetic flux phi of the d shaft current id, the q shaft current iq, q shaft electrical potential difference vq, rotational speed omega and d shaft inductance Ld, q shaft inductance Lq, primary resistance R, and a permanent magnet.
[0024] The reason for acquiring effectiveness with the magnetic-flux correction means 13 is explained to the

second. If the temperature presumption machine 12 shows temperature-change deltatheta of a permanent-magnet type synchronous motor [illegible]usted value phin of the magnetic flux [illegible]e permanent magnet by temperature-change deltatheta can be calculated from (5) types.

[0025]

[Effect of the Invention] As stated above, according to this invention, it can correct to a right value, without being concerned with fluctuation according the magnetic flux and primary resistance of a permanent magnet to a temperature change, the highly precise torque control in a permanent-magnet type synchronous motor becomes possible, and it is greatly useful practically.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a block diagram showing one example of this invention.
[Drawing 2] It is a block diagram showing one example of the conventional method.
[Description of Notations]
1 Permanent-magnet Type Synchronous Motor
2 Rate Detector
3 Electrical-Potential-Difference Detector
4 Current Detector
5 Power Converter
6 Current Limiter
7 Q Shaft Current Command Calculation Machine
8 D Shaft Current Command Calculation Machine
9 Current Component Converter
10 Setting Storage Means
11 Voltage Component Converter
12 Temperature Presumption Machine
13 Magnetic-Flux Correction Means

[Translation done.]

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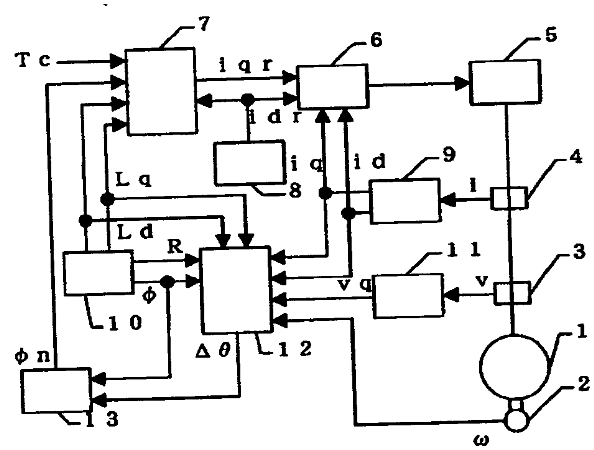
(54)【発明の名称】 永久磁石型同期電動機の制御装置

(57)【要約】
【課題】 永久磁石型同期電動機の温度変化を推定して、高性能な制御を行う。
【解決手段】 永久磁石型同期電動機の入力電圧を検出する電圧検出器及び、電圧検出器の出力からｑ軸電圧を抽出して出力する電圧成分変換器を有し、永久磁石型同期電動機の回転速度を検出する速度検出器を有し、設定記憶手段に永久磁石型同期電動機の一次抵抗を設定記憶し、ｄ軸電流、ｑ軸電流、ｑ軸電圧、回転速度、設定記憶手段の一次抵抗と磁束とから永久磁石型同期電動機の温度変化を推定する温度推定器と、設定記憶手段の磁束と温度推定器の出力とから、ｑ軸電流指令算出器に用いる磁束を修正する磁束修正手段を具備する。



【特許請求の範囲】

【請求項１】　永久磁石型同期電動機の制御装置において、電流制御器出力を制御入力とする電力変換器を介して永久磁石型同期電動機に供給される入力電流を検出する電流検出器と、この電流検出器出力を前記永久磁石型同期電動機の永久磁石と平行方向であるｄ軸電流と垂直方向であるｑ軸電流とに変換出力する電流成分変換器と、前記永久磁石の磁束及び一次抵抗を設定記憶する設定記憶手段と、ｄ軸電流指令を算出するｄ軸電流指令算出器と、前記永久磁石型同期電動機の出力トルク指令値と前記設定記憶手段の磁束及びｄ軸電流指令とからｑ軸電流指令を算出するｑ軸電流指令算出器と、前記ｄ軸電流とｑ軸電流及びｄ軸電流指令とｑ軸電流指令とを入力とする電流制御器と、前記永久磁石型同期電動機の入力電圧を検出または推定する電圧検出器と、この電圧検出器出力から前記永久磁石と垂直方向であるｑ軸電圧を出力する電圧成分変換器と、前記永久磁石型同期電動機の回転速度を検出する速度検出器と、前記のｄ軸電流、ｑ軸電流、ｑ軸電圧、回転速度、設定記憶手段の一次抵抗と磁束の各値とから前記永久磁石型同期電動機の温度変化を推定する温度推定器とを具備したことを特徴とする永久磁石型同期電動機の制御装置。

【請求項２】　前記設定記憶手段の磁束と前記温度推定器出力とから、前記ｑ軸電流指令算出器に用いる磁束を修正する磁束修正手段を具備したことを特徴とする請求項１記載の永久磁石型同期電動機の制御装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、永久磁石型同期電動機におけるトルク制御に関するもので、特に温度変化によるトルク精度の変動を改善するものである。

【０００２】

【従来の技術】従来技術の一例を図２に示し、これについて説明する。電力変換器５は、永久磁石型同期電動機１に電力を供給する。電流検出器４は永久磁石型同期電動機１の入力電流ｉを検出する。電流成分変換器９は、入力電流ｉを入力とし、永久磁石型同期電動機１の永久磁石と平行方向であるｄ軸電流ｉｄと、垂直方向であるｑ軸電流ｉｑとを出力する。設定記憶手段１０は、永久磁石型同期電動機１のｄ軸インダクタンスＬｄとｑ軸インダクタンスＬｑと永久磁石の磁束φとを設定記憶する。

【０００３】ｑ軸電流指令算出器７は、トルク指令Ｔｃと、ｄ軸電流指令ｉｄｒと、ｄ軸インダクタンスＬｄとｑ軸インダクタンスＬｑと永久磁石の磁束φとを入力してｑ軸電流指令ｉｑｒを出力する。ｄ軸電流指令算出器８は、ｄ軸電流指令ｉｄｒを出力する。電流制御器６は、ｄ軸電流ｉｄ、ｑ軸電流ｉｑ、ｄ軸電流指令ｉｄｒ、ｑ軸電流指令ｉｑｒとを入力し、各電流値が指令値に追従するよう制御信号を電力変換器５へ出力する。

【０００４】

【発明が解決しようとする課題】永久磁石型同期電動機のトルク式は、次式で表される。

【０００５】

$$T=\phi\bullet i_q+\left(L_d-L_q\right)\bullet i_d\bullet i_q \qquad (1)$$

【０００６】（１）式より、ｑ軸電流指令ｉｑｒは、次式のように求められる。

【０００７】

$$i_{qr}=\frac{T}{\phi+\left(L_d-L_q\right)\bullet i_{dr}} \qquad (2)$$

【０００８】（２）式より、ｑ軸電流指令ｉｑｒは永久磁石型同期電動機のｄ軸インダクタンスＬｄとｑ軸インダクタンスＬｑと永久磁石の磁束φとを用いて算出される。ところが、永久磁石の磁束φは永久磁石型同期電動機の温度変化によって変動するため、永久磁石の磁束φを固定しておくと、温度変化によって（２）式のｑ軸電流指令値ｉｑｒが正しい値として算出されず、永久磁石型同期電動機の出力トルクの制御精度が変動する結果となる。本発明は上述した点に鑑みて創案されたもので、その目的とするところは、永久磁石型同期電動機の温度変化を推定し永久磁石の磁束の温度変化による変動を修正する機能を設けることで上記問題点を解決し、さらに永久磁石型同期電動機のトルク制御を高精度化するものである。

【０００９】

【課題を解決するための手段】上記問題点を解決するため、電流制御器出力を制御入力とする電力変換器を介して永久磁石型同期電動機に供給される入力電流を検出する電流検出器と、この電流検出器出力を前記永久磁石型同期電動機の永久磁石と平行方向であるｄ軸電流と、垂直方向であるｑ軸電流とに変換出力する電流成分変換器と、前記永久磁石の磁束及び一次抵抗を設定記憶する設定記憶手段と、ｄ軸電流指令を算出するｄ軸電流指令算出器と、前記永久磁石型同期電動機の出力トルク指令値と前記設定記憶手段の磁束及びｄ軸電流指令とからｑ軸電流指令を算出するｑ軸電流指令算出器と、前記ｄ軸電流とｑ軸電流及びｄ軸電流指令とｑ軸電流指令とを入力とする電流制御器と、前記永久磁石型同期電動機の入力

電圧を検出または推定する電圧検出器と、この電圧検出器出力から前記永久磁石と垂直方向であるｑ軸電圧を出力する電圧成分変換器と、前記永久磁石型同期電動機の回転速度を検出する速度検出器と、前記のｄ軸電流、ｑ軸電流、ｑ軸電圧、回転速度、設定記憶手段の一次抵抗と磁束の各値とから前記永久磁石型同期電動機の温度変化を推定する温度推定器とを具備する。

【００１０】また、前記設定記憶手段の磁束と前記温度推定器出力とから、前記ｑ軸電流指令算出器に用いる磁束を修正する磁束修正手段を具備する。

【発明の実施の形態】

【００１１】本発明の実施例を図１に示し、以下、この図について説明する。なお、前述の従来技術例と同一部分の説明は省略する。速度検出器２は、永久磁石型同期電動機１の回転速度ωを出力する。電圧検出器３は、永久磁石型同期電動機１の入力電圧ｖを検出または推定する。電圧成分変換器１１は、入力電圧ｖから、永久磁石型同期電動機１の永久磁石と垂直方向であるｑ軸電圧ｖｑを出力する。

【００１２】温度推定器１２は、ｄ軸電流ｉｄとｑ軸電＊

＊流ｉｑとｑ軸電圧ｖｑと回転速度ωとｄ軸インダクタンスＬｄとｑ軸インダクタンスＬｑと一次抵抗Ｒと永久磁石の磁束φとを入力し、永久磁石型同期電動機１の温度変化Δθを出力する。磁束修正手段１３は、永久磁石の磁束φと温度変化Δθとを入力し、修正された永久磁石の磁束φｎを出力する。

【００１３】ｑ軸電流指令算出器７が従来技術と異なる点は、修正された永久磁石の磁束φｎを用いている点である。設定記憶手段１０が従来技術と異なる点は、一次抵抗Ｒを設定記憶している点である。

【００１４】ここで、本発明によって、前記問題点を解決できる二つの理由について説明する。第一は、永久磁石型同期電動機の温度変化が推定できる理由であり、第二は磁束修正手段により効果を得る理由である。まず第一に、永久磁石型同期電動機の温度変化が推定できる理由についてであり、温度推定器１２の詳細について説明する。永久磁石型同期電動機1のｑ軸電圧方程式は、次式で表される。

【００１５】

$$v_q=\omega\bullet L_d\bullet i_d+\left(R+p\bullet L_q\right)\bullet i_q+\omega\bullet\phi \qquad (3)$$

【００１６】ここで、ｐは微分演算子である。（３）式において、温度変化Δθによって変動するものは、永久磁石の磁束φと一次抵抗Ｒとがある。温度変化Δθによる永久磁石の磁束φと一次抵抗Ｒの変動量は、温度変化※

※Δθと比例関係である。よって、実際の永久磁石の磁束φｎと一次抵抗Ｒｎは、次式の関係で表すことができる。

【００１７】

$$R_n=\left(1+g_1\bullet\Delta\theta\right)\bullet R \qquad (4)$$

【００１８】

$$\phi_n=\left(1+g_2\bullet\Delta\theta\right)\bullet\phi \qquad (5)$$

【００１９】ただし、ｇ１、ｇ２は温度係数である。よって、実際の一次抵抗Ｒｎの（４）式と永久磁石の磁束φｎの（５）式を（３）式に代入すると、温度変化Δθ★

★は次式となる。

【００２０】

$$\Delta\theta=\frac{v_q-\omega\bullet L_d\bullet i_d-\left(R+p\bullet L_q\right)\bullet i_q-\omega\bullet\phi}{g_1\bullet R\bullet i_q+g_2\bullet\omega\bullet\phi} \qquad (6)$$

【００２１】よって温度推定器１２では、（６）式を変形した次式の演算を行って温度変化Δθを推定する。☆

☆【００２２】

$$\Delta\theta=K\int\left[\left\{v_q-\omega\bullet L_d\bullet i_d-\left(R+p\bullet L_q\right)\bullet i_q-\omega\bullet\phi\right\}-\Delta\theta\bullet\left(g_1\bullet R\bullet i_q-g_2\bullet\omega\bullet\phi\right)\right]\bullet dt \qquad (7)$$

【００２３】ここで、Ｋは積分定数である。温度変化Δθが小さければ（７）式の[　]中の演算値が正となって温度変化Δθを増加させ、逆に温度変化Δθが大きければ（７）式の[　]中の演算値が負となって温度変化Δθを減少させることで温度変化Δθを推定することができる。以上説明したように、ｄ軸電流ｉｄとｑ軸電流ｉｑとｑ軸電圧ｖｑと回転速度ωとｄ軸インダクタンスＬｄとｑ軸インダクタンスＬｑと一次抵抗Ｒと永久磁石の磁束φとから永久磁石型同期電動機の温度変化Δθを推定することができる。

【００２４】第二に、磁束修正手段１３により効果を得る理由について説明する。温度推定器１２によって永久磁石型同期電動機の温度変化Δθが分かれば、（５）式より温度変化Δθによる永久磁石の磁束の修正値φｎが演算できる。

【００２５】

【発明の効果】以上述べたごとく、本発明によれば、永久磁石の磁束と一次抵抗とを温度変化による変動に関わることなく正しい値に修正できるようになり、永久磁石型同期電動機での高精度なトルク制御が可能となって、実用上おおいに有用である。

【図面の簡単な説明】

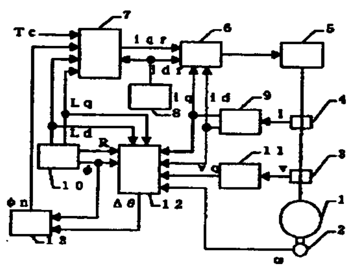
【図１】本発明の一実施例を表すブロック図である。

【図２】従来方式の一実施例を表すブロック図である。

【符号の説明】

１　永久磁石型同期電動機
２　速度検出器
３　電圧検出器
４　電流検出器
５　電力変換器
６　電流制御器
７　ｑ軸電流指令算出器
８　ｄ軸電流指令算出器
９　電流成分変換器
１０　設定記憶手段
１１　電圧成分変換器
１２　温度推定器
１３　磁束修正手段

【図１】



【図２】